



1. 16A01 -- General Technical

The Design Engineer shall refer to Section 1 for information on Technical Programming, Document Requirements, Consultant Responsibilities, Abbreviations, and Submittal Requirements.

A. Scope

1. These standards and procedures contain the design criteria for electrical systems and architectural provisions, general requirements for submittals, equipment approvals, and post-installation instruction and reference materials. They shall apply to all sections of the electrical division. Also included are important areas of design to coordinate with Plant Engineering and Cross References to electrical information in other sections.
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B. General Requirements

1. All work shall conform to the following codes, regulations and standards of latest adoption, other applicable codes; and industry standards:
 - a. National Electrical Code
 - b. National Electrical Safety Code
 - c. State of Washington Electrical Construction Code
 - d. State of Washington Department of Labor and Industries Regulations
 - e. Seattle Fire Codes
 - f. Seattle Building Codes
 - g. Seattle Electrical Code Supplement
 - h. Seattle Energy Code
 - i. NEMA
 - j. NFPA
2. The majority of City construction is for permanent installation. Therefore, all electrical systems must be designed for an anticipated 30 to 40 year life span before requiring major repairs or replacements.
3. Systems and components must be designed with maximum reliability, maximum flexibility, and minimum operation and maintenance costs in mind.



- a. Flexibility is important in the system design. Full consideration must be given for future system alterations and additions with a minimum of system shutdowns.
 - b. Normal preventative and routine maintenance must be accomplished without major building shutdowns.
4. Where a detailed analysis of the program reveals an inadequate budget to provide the appropriate system design, notify the Owner, in writing, of the budget deficiency, the recommended system and its cost, and the alternatives if a budget revision is not provided.
5. Logistics
 - a. Contractor access to the City facilities may be restricted. Planning should be done to verify that the Contractor has space for a job shack and materials storage within a reasonable distance of the project.
 - b. Unloading space near the project can also be a problem. Loading docks are generally in use constantly for facility servicing, and construction materials typically cannot be left on the loading dock for any length of time.
 - c. Any necessary road closures for unloading or crane work needs to be carefully coordinated with City personnel.
 - d. Locations of construction equipment producing exhaust or fumes may need to be restricted to eliminate nuisance and hazards to interior spaces.
6. Construction Limitations
 - a. Primary switch cubicles can exceed the height of standard doorways. Allowances should be made for installation, and changes or additions to switchgear sections during the life of the building.
 - b. Weights of transformers could exceed floor loadings if other than slab-on-grade basement areas are necessary for installation. Make sure that lifting eye and floor loading are accommodated in the design. Seismic supports and restraints are necessary.
 - c. Temporary fire alarm measures may be necessary to avoid disruption of exiting patterns, and during shut downs for additions to the fire alarm system. Be sure to evaluate the cost of such temporary measures in the project estimate.
 - d. In remodel projects, shutdowns of existing feeders and services may be necessary. These shutdowns may have to occur after normal working hours to prevent interruption of critical operations. The cost of such premium working hours can have a major impact on the construction estimate. Also, temporary power may be necessary to maintain service to critical loads.
 - e. Operation of power tools may have to be scheduled with the owner to reduce the noise impact on day-to-day operations of the facilities.



7. Controls

There are several existing control systems on the site from energy management to fire alarm systems. Interfacing new systems into the existing systems needs to be carefully coordinated, both from the installation standpoint of the contractor and the interface with existing systems operated by the City.

8. Equipment Identification nomenclature shall be coordinated with Plant Engineering.

9. Design Considerations

- a. Identify and evaluate any necessary alternates early in the design process.
- b. Constructibility: The construction sequence may need to be itemized as part of the contract so that the Owner and the Contractor may reliably predict and schedule outages, space access and business interruptions. If there are long lead items that impact the construction schedule, they should be identified early for possible owner purchase. Specific areas of coordination need to be identified to alert the contractor to special work area problems.
- c. Construction Cost Estimates and Schedules: Evaluation of the bid market should be made. The impact of remodel work, crowded working and access spaces, equipment delivery time, and possible premium overtime hours should all be factored into the project cost estimate and schedule, and clearly stated in the construction contract.

10. Demolition and Remodel

- a. Phasing of work to allow shutdowns to occur may extend construction time.
- b. Disposal of materials can be a problem with limited on-site areas for temporary storage. Define reuse of equipment where appropriate.
- c. Correcting existing panel schedules, removing conductors and raceways of abandoned circuits, and maintaining existing circuits being modified all need addressing in the contract documents.
- d. In general, the abandonment of equipment and raceways in place is not acceptable. Space shall be conserved as much as possible.

C. Interdiscipline Coordination

The Engineer shall coordinate the electrical work with other specification sections to completely define the work and responsibilities of the electrical contractor. Indicate control wiring interfaces between systems.

- 1. Hardware.
- 2. Kitchen equipment.
- 3. Mechanical equipment.



4. Architectural specialties.
5. Elevator/escalator: Include machine room, hoistway, and pit lighting, receptacles, and communication outlets.
6. Shop equipment.

D. Important Areas of Coordination with Plant Engineering

1. Service conductor taps and service classifications.
2. Electrical room locations, sizes, and equipment arrangements within these rooms (for all service equipment and floor distribution electrical rooms.)
3. Distribution concepts including grounding, calculated fault duties and protective relay coordination methods.
4. Connected and demand load calculations for power system.
5. Connecting to existing distribution systems including capacity and location.
6. Situations where spare parts inventories and operational reliability are a concern such that Equipment specifications which limit the number of vendors and assure quality must be written.
7. Special considerations for operations and maintenance to reduce the impact of noise, outages, and testing.
8. All shutdowns must be carefully coordinated with City staff, and can take several weeks of planning so all affected departments can plan operations around them. Delays in the construction schedule may be necessary and should be considered in the establishment of the completion date. The schedule shall be confirmed just before work begins and during construction.

E. Cross References

The following sections are itemized for specific references to electrical information in other FDI sections:

1. Volume 1:
 - a. Drafting and CAD Standards
 - b. SD-E-100 through SD-E-119 (Standards Drawings for electrical symbols)
 - c. SD-CM-1 (Standards drawing for communication symbols)
 - d. SD-FA-1 through SD-FA-3 (Standards Drawings for fire alarm symbols)
2. Volume 2:
 - a. 02440 Irrigation Systems



- b. 10000 Specialties
- c. 11640 Fume Hoods
- d. 14200 Elevators. Fire alarm interface and coordinate for absorption of regenerated power if necessary.



2. 16A02 -- Requirements for Electrical Rooms and Spaces

A. Scope

1. Following are requirements for electrical rooms and spaces. Coordinate with architect, mechanical, civil and other consultants for complete work definition.
2. Index:

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B. General

1. Provide concrete bases and housekeeping pads for all transformers and equipment, seismically designed with structural connections to floor slab, and channel or angle iron frames for welded equipment fastening.
2. Design for future removal or replacement of transformers and provide ventilation for removal of heat generated by the transformers.
3. Provide supports and restraints for Seismic Zone III requirements for all equipment and raceways.
4. Provide separate rooms or closets for communications equipment.
5. Coordinate layout with Plant Engineering and plant electricians.
6. See 16190 for anchoring and fasteners.

C. Building Electrical Service Rooms

1. Install all medium voltage services for buildings in rooms or spaces with concrete or solid masonry walls and ceilings.
2. In general, allocate floor space for future switchgear.
3. The building service room shall contain the primary interrupter switch, the service transformer, and the service switchboard. The preferred configuration of this equipment is in the form of a unit or packaged substation. See SD-E-121 for typical working space requirements. Allow clearances in excess of NEC for safety and maintenance convenience.
4. The building service room may also house other related secondary distribution equipment.
5. The room design shall take into consideration the possibility of flooding when below grade.



6. Equipment and transformer rooms must be designed with consideration for the following features:
 - a. Convenient conduit and cable entrance.
 - b. Walk-in access for personnel from within the building.
 - c. Adequate doors, hatchways, etc., to permit ready installation or removal of major equipment items such as transformers, motors, controls, switchboards, etc. Provide exit paths per NEC.
 - d. Standard Physical Plant Department keying to limit access to authorized personnel.
 - e. Adequate ventilation completely separate from the building ventilating systems. A gravity type system is preferred when sufficient exterior wall area is available.
 - f. An areaway may serve the function for both equipment removal and ventilation.
 - g. Mechanical piping and ductwork must not be installed in electrical equipment and transformer rooms except where required for operation of the electrical equipment.
 - h. Piping and ductwork must never be installed directly over any transformer or switchgear. Sprinklers are the only exception, if installed to protect electrical equipment.
 - i. Adequate lighting, ventilation, and sound control must be provided, including emergency lighting and receptacles, if emergency system is available.

D. Electrical Rooms and Closets

1. Electrical rooms and closets must be provided for installation of panels and equipment and for vertical wiring. In multi-story buildings, they must be located on each floor with risers in direct vertical alignment.
2. Distribution switchboards and panelboards, and dry transformers over 30 KVA, shall be in electrical rooms. Rooms shall stack for riser efficiency, and be centrally located to keep feeder lengths minimum. Several rooms may be necessary to accommodate the building configuration and system design.
3. As a general guide, provide one floor electrical distribution room to serve each 15,000 to 20,000 square feet.
4. See SD-E-136 for typical electrical room layout. Mechanical ventilation is required for spaces containing transformers as are equipment replacement clearances and removal routes.
5. Branch panels may be located in closets located throughout the floor or wing.
 - a. Closets should be a minimum size 2 feet deep by 6 feet wide, equipped with full width double doors opening into a building corridor.



- b. Closet doors must be equipped with standard Physical Plant Department keying to limit access to authorized personnel. Doors will normally not be keyed to the building master system.
 - 6. In shops or similar areas, branch panels may be mounted on or in walls.
 - 7. Special attention must be given to the design of the floor structure to permit future openings in the slab without weakening the structure. Provide capped sleeves, knockouts and floor space for future conduit.
- E. Corridors
- Corridors should have accessible type ceilings constructed of readily removable "lift-out" panels to permit access to electrical and communications services.
- F. Offices and Miscellaneous Rooms
- Offices and miscellaneous rooms shall have accessible type suspended ceilings whenever possible.



3. 16A04 -- Service and Distribution (600 volt and below)

A. Scope

1. This section applies to the design of building secondary power service and distribution at 480Y/277 and 208Y/120 volts, from the secondary of the service transformer to the branch circuit outlets or utilization equipment.
2. Coordinate system design and equipment layout with Electrician.
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B. Short Circuit Study

1. The Consultant shall prepare a short circuit study at the design development phase, and evaluate potential coordination and interrupting capacity problems. The purpose of the initial study is to verify coordination of the proposed electrical equipment. It is possible that not all of the purchased protection equipment will be from the same manufacturer with the end result being unacceptable overlapping time current curves.
2. The initial study shall contain the fault and load current values listed at key points on the distribution system one-line diagram to illustrate the necessary equipment fault duty.
3. The consultant shall propose solutions to any problems, and demonstrate that coordination can be achieved with the proposed devices. Specify the electrical equipment with enough flexibility to allow field solutions on the installed system.

C. General Building Services and Distribution

1. Service and Distribution Methods
 - a. It is the objective of this design criteria to provide building service reliability commensurate with the needs of the facility's designed usage. Facility designed usage has been categorized into three (3) general normal power classes and three (3) general emergency power classes: See Section 16A03.



- b. The City's Tech Services and Project Management Departments will participate in the selection of the building service configuration.

- c. Normal Power

- (1) Provide main power and lighting distribution in new buildings and renovations at 480Y/277 volts, 3 phase, 4 wire solidly grounded. Serve convenience receptacles, special equipment and special lighting from a 208Y/120 volt, 3 phase, 4 wire solidly grounded system established by means of one or more dry-type transformers throughout the building.
 - (2) See Standard Drawing SD-E-131 for the suggested building distribution concept.
 - (3) In general, smaller (maximum 800A) conduit and cable risers are preferred over bus way risers for convenience in maintenance shut downs, and limiting disruptions during faults and repair.

- d. Emergency Power

Emergency lighting and power shall hook up to existing emergency power system or where none exists to the public and pathway lights.

System Requirements will be decided on an individual building basis. The design team and the City Project Management Team, Facilities, and Engineering Staff shall be included in the decision making process for each project.

- 2. Equipment Specifications

- a. All building services should be designed to limit the maximum available fault current to 50,000 amps or less.
- b. Select all equipment with full consideration for overcurrent protection, phase and ground fault selectivity (use zone-selective interlocking where beneficial), fault current interrupting, and fault closing capabilities, as well as current carrying capacity.
- c. Determine the requirements from the ultimate installed transformer capacity programmed for the building.
- d. Breakers and current limiting circuit breakers are preferred in lieu of fused switches and fused breakers.
- e. Each building shall have a main service switchboard(s) with main disconnect(s), tie breakers (where required), necessary feeder breakers, and metering. Unless otherwise directed, the application will be a 480/277 volt, 3 phase, 4 wire distribution system.

- 3. Electrical Rooms and Closets

- a. See 16A02 for the building electrical service room specification.



- b. See 16A02 and SD-E-132 for electrical rooms and closets on each floor. Size rooms with future panel and riser space. Accounted for in space provided.
- c. Distribution switchboards and panelboards, and dry transformers over 30kva, shall be in electrical rooms.
- d. Electrical closets may be used for floor branch panels and transformers 30kva and smaller, and riser panels not serving over three floors, to supplement electrical rooms. There shall be no storage in panel rooms.

4. Additional Considerations

Secondary system design must give full consideration to future expansion, maintenance, and alterations by use of the following features:

- a. Switchboards and motor control centers located and arranged to permit installation of additional sections or cubicles.
- b. Spare full size breaker or space with hardware for maintenance backfeed operations.
- c. Panels with spare breakers, or space for additional breakers.
- d. Spare conduits or sleeves to minimize core drilling in the future.
- e. Surface raceways for multiple outlet areas.

D. Switchboards

1. General

All switchgear should be reviewed before approval. Price listing of breakers listed and a physical sample should be available for inspection. The physical example can be an existing panel on site.

Cutler Hammer is our preferred manufacturer because of readily available parts and a large inventory of spare breakers used for temporary panels.

- a. The switchboard should have an adequate number of spare feeder breakers, spaces for hardware for future feeder breakers, and provisions for adding vertical sections onto one end.
- b. Each of the circuit breakers should be provided with overcurrent and, as required, ground fault relay protection. A breaker tripping scheme should be specified that will not require an alternate source of control power. The settings for overcurrent and ground fault protective devices should be chosen to provide a completely selectively coordinated system.
- c. Provide Ground Fault Protection as Follows:



- (1) All services (unless programmed otherwise) shall be provided with GFP per NEC.
- (2) When ground fault protection is used on the main there should also be ground fault protection on the sub-feeders.
- e. Provide status monitoring dry contacts on the following breakers for open, closed, and trip conditions for mains, ties and feeders for building services.
- f. When viewing the switchboard from the front, specify:
 - (1) Phase relationship (A-B-C) shall be left-right, top-bottom, front-back.
 - (2) Low voltage switchgear connected to building power service transformers have their buses identified 1-2-3.
 - (3) Connections between the transformer low voltage terminals and the switchgear shall be as follows:
 - "X1" to "1" (Bus)
 - "X2" to "2" (Bus)
 - "X3" to "3" (Bus)

It is to be noted that transformer connections as indicated above will result in a rotation sequence at the low voltage switchgear of 1-2-3.)
- g. Aluminum bus is allowed if insulated.

2. Switchboard Designations

The City has designated switchboards (400 amps and larger) into the three following types:

- a. Type A:
 - (1) Bus 1600A and above, and all service switchboards.
 - (2) Similar to GE AKD-8, Siemens type R, or Square D Powerzone II; with hinged rear and front access panels for breaker and metering compartments.
 - (3) Insulated and isolated bus, with fully rated horizontal phase and neutral buses. Aluminum bus acceptable.
 - (4) Isolated compartments for all breakers.
 - (5) Draw-out air circuit breakers, 100% rated, stored energy opening and closing, with electronic static overcurrent, ground fault, current limiting fuses, and zone selective interlock protection. Integral current limiting fuses on tie and feeder breakers.



- (6) Bus and connecting stubs for individual breakers sized for the full capacity of the breaker frame size and not for the trip setting of the overcurrent devices.
 - (7) 800 amp minimum breaker frame size.
 - (8) Specifications - see 16425.
 - b. Type B:
 - (1) Bus 801 through 1600A.
 - (2) Use GE "AV-3", square D or Siemens.
 - (3) Insulated and isolated continuous main bus and full neutral bus, also with hinged rear and front access panels for breaker and metering compartments in feeder compartments. Aluminum bus acceptable.
 - (4) Main and tie breakers draw-out air circuit breaker type, with stored energy opening and closing.
 - (5) Feeder breakers may be stationary mounted molded case type, with interchangeable thermo-magnetic trip units.
 - (6) Minimum size breaker 100A.
 - c. Type C:
 - (1) 401A through 800A.
 - (2) Use GE "AV-2" square D or Siemens, with group mounted feeders and individually mounted main. Copper busing. Hinged wiring compartment doors with captive screws.
 - (3) Molded case mains and feeders, except when serving service entrance.
 - (4) Wall mount panelboard construction with group mounted main permissible when not a service entrance. Copper busing.
 - (5) Provide door over circuit breaker handles.
- 3. Service Equipment
 - a. Service entrance label required for all building service switchboards, and all side load switchboards or panelboards of derived sources.
 - b. All metering on services shall be as specified in 16425.
 - c. On services from a utility company, provide metering to suit their requirements. Provide space for clamp-on type metering where service is subfed from other campus structure.



4. Additional Switchboard Specifications
 - a. Accessories such as breaker racking devices, integral extension rails, breaker lifting devices, and maintenance closing handles.
 - b. Shop drawings, wiring diagrams, maintenance manuals, and overcurrent device time-current characteristic curves.
 - c. Additional ground bus for 208Y/120 volt equipment.

E. Distribution Feeders

1. Equipment grounding conductors shall be included in all raceways. Isolated ground conductors on 208 volt systems shall be included in raceways when required and allowed by NEC 250-74 Exception 4 . Indicate on feeder schedules and circuiting.
2. Provide panel and feeder identification.
3. For wiring continuity, phase identify all feeder cables.
4. Consider the neutral as a current carrying conductor.
5. Specify circuit breaker lugs to match feeder size. Splitting single conductor to two smaller taps to accommodate parallel lugs on a breaker is not acceptable.
6. Switching mode power supplies can generate harmonic currents The harmful effect of these currents on distribution feeders and equipment must be considered in the design process.

F. Distribution Panels

1. Construct as non-service type B or C switchboards depending on size.
2. Copper busing only.
3. Provide additional isolated ground bar for 208Y/120 volt systems.
4. Derived source distribution panels shall have service entrance label.
5. Panel must have a main breaker.

G. Dry Type Transformers

1. Utilize as required to provide 208/120v, 3 phase, 4 wire service from the building 480 volt distribution system. Connect delta-wye.
2. Air cooled dry-type with steel housing enclosing all wiring and connections; have built-in vibration isolators.
3. Insulated/isolating type with class H insulation with an average temperature rise not to exceed 150C. based on a 40C. ambient temperature. Shielded type may be advisable for certain applications.



4. Six fully rated taps on the primary winding for each transformer: three 2-1/2 percent taps below normal and three 2-1/2 percent taps above normal.
5. Transformers shall be located to assure adequate ventilation. Provide heat gain calculations for space involved to verify adequate ventilation. Mechanical ventilation is probably necessary. Space away from walls at least as far as the width of the ventilation opening, or per U.L. listing.
6. Do not locate heat sensitive equipment or equipment requiring working clearance above transformers.
7. Dry transformers may be a source of noise, heat, and vibration problems. High quality equipment, special mounting arrangements, sound isolation, etc., may all need detailing in the specifications and on drawings. Suspended platform mountings for transformers must be coordinated with the structural engineer, as well as floor loadings. Wall mounted transformers shall be limited to 30 KVA and below.
8. A local primary side disconnect is not required if the transformer has a local secondary disconnecting means.

H. Branch Circuit Panelboards

1. Locate panels in electrical rooms, electrical closets, or utility hallways on each floor. Special rooms with highly concentrated loads should have separate panels. Panels should not be located in janitor closets or toilet room entries. As much as possible, locate panels near columns, on permanent corridor walls, or other permanent features, to reduce the chance of having to relocate panels on remodel projects. (See also 16A05.)
2. Surface mounted panels are preferred to flush panels. Surface mount panels in utility spaces. In finished areas provide flush mount with full height access to ceiling for future raceways. All flush panelboards shall have a minimum of (3) 3/4" conduits stubbed out above panel into accessible ceiling space.
3. Provide door-in-door construction with lockable metal latch fasteners on all doors. When more than one fastener is required on a door, provide single operator handle with multi-point fasteners. Locks shall be keyed alike and to match the existing standard keying system. Opening outer door should expose terminals and circuit breakers in a single operation.
4. Provide all 208Y/120 volt panels located in office areas with a dedicated, isolated, full size ground bus to serve future computer equipment, and a separate equipment grounding conductor bus. Provide terminals for a minimum of 50% of panel circuits on each bus. Connect to derived system ground. See "grounding" section.
5. Panels served by oversized feeders may require larger enclosures for bending space.
6. Circuit breaker type, equipped with "bolted-in" breaker units. Equipment must be provided with adequate interrupting capacity. Minimum interruption capacity for each panel shall be 10,000 AIC or as calculated, whichever is higher.



7. Panelboard designations shall be labeled on the front of the panel and on the directory to agree with as-built drawings.
8. Number panel circuits to correspond with the panel schedule. Each panel shall be provided with clear plastic covered typewritten circuit directory.
9. Provide copper busing.

I. Branch Circuit Wiring

1. Definitions
 - a. **Dedicated Circuit:** A branch circuit with phase, neutral and ground conductor serving only designated loads. No other outlets to share neutral or phase conductors.
 - b. **Dedicated Outlet:** A single outlet on dedicated branch circuit.
 - c. **Isolated Ground Circuit:** An electrical branch circuit which includes a ground wire which is electrically insulated from all other electrically conductive items except at the point of origination of the circuit. It achieves a degree of freedom from interference. The ground is terminated at an isolated ground bus.
 - d. **Isolated Ground Bus:** A ground bus which is electrically insulated from adjacent conductive surfaces and which is electrically connected to a selected reference point.
2. General
 - a. Minimum conductor size shall be #12. Home runs greater than 75 feet to the first receptacle outlet shall be #10. Evaluate necessary longer runs and size to suit voltage drop limitations. As a rule keep 120 volt circuits to less than 75 feet, 277 volt circuits to less than 125 feet. Maximum branch circuit voltage drop to be 3%.
 - b. Original circuit loading shall not exceed 1,600 watts on 20 ampere, 120 volt circuits; 3,800 watts on 20 ampere, 277 volt circuits.
 - c. Common neutrals are permitted in a single conduit for two or three single phase circuits served from different phases when objectionable harmonic currents from fluorescent fixtures, electric discharge lighting, computers, etc. do not exist. The Contractor should be cautioned not to reconnect common neutral circuits to the same phase when balancing panel loading.
 - d. Office electrified or wired furniture partitions to have neutrals sized at 200%, or separate neutrals per circuit.
 - e. Microwave ovens, refrigerators, hot plates, water heaters to be on dedicated circuits, on normal power.
 - f. Each branch circuit raceway shall contain a green equipment grounding conductor in addition to the phase and neutral conductors. Indicate on branch circuits on plans, and size if other than #12.



- g. Isolated ground circuits shall contain an additional grounding conductor.
 - 3. Harmonic Currents: Switchmode power supplies, dimmers, variable frequency drives, etc., may create harmonic distortion and neutral current in excess of phase currents, provide properly sized lugs as required for larger conductors. As a guide, in lieu of specific data on equipment, use:
 - a. Oversized (#10) neutral on 120 volt receptacle circuits sharing a neutral is the preferred design as this provides the least voltage drop; however, separate neutrals are required for dedicated circuits
 - b. Double size neutral for 3 phase branch circuits.
 - c. Disconnect panelboard and neutrals sized at 200% of phase conductor.
 - d. If total panel load includes over 30% switchmode power supplies, derating of transformers, generators, and power supplies may be required, and other circuit adjustments necessary.
- J. Raceways See 16110.
- K. Wiring Devices and Plates
 - 1. Use specification grade self-grounding devices in general; 20 amp for dedicated outlets. 15 amp for multiple outlets on 20 amp circuits acceptable. Hard ground pigtails are to be connected at all times. Do not rely on self-grounding feature.
 - 2. AC only "quiet" type switches, 20 ampere rating, self grounding. White color for normal power. Interchangeable type devices may be used only for special applications when approved by the Architect. Locking switches - use Leulton (1201-2L).
 - 3. Use neon or low voltage transformer-base types Pilot lights for long life and ruggedness.
 - 4. Provide 120 volt convenience receptacles in janitor closets, toilet rooms, corridors, pipe tunnel and other special purposes spaces for maintenance department use. Receptacle locations in offices, classrooms, etc., shall be determined by the occupancy of the room. In corridors, receptacles for cleaning shall be provided at spacing not to exceed 50 feet near hallway intersection and rear entry vestibules on circuits separate from office circuits. Additionally provide janitorial receptacles in stairs at each floor landing. In general, each circuit's overcurrent device should be on the same floor as the outlets.
 - 5. If emergency system exists in a particular building, provide at least one 120 volt convenience receptacle in each mechanical, electrical and communications room connected to the building standby emergency panel for emergency maintenance use, in addition to normal power receptacles.
 - 6. Receptacle configuration shall conform to NEMA Standards.
 - 7. Locate GFCI exterior weatherproof convenience receptacles adjacent to each entry way.



8. Provide ground fault circuit interrupter (GFCI) receptacles as dictated by good engineering practice. Use master/slave arrangement. Reset must be accessible by users.
 - a. Follow NEC rules for residential use to determine need for GFCI in all areas.
9. Device Plates
 - a. Stainless steel for devices in finished areas unless otherwise specified.
 - b. Galvanized or cast to suit box when exposed wiring permitted.

L. Grounding

1. Proper grounding is a very important aspect of all electrical installation. The Specifications shall state, "all electric systems, components, and devices shall be properly grounded per National Electrical Code," and SD-E-133 through SD-E-139.
2. A maximum resistance to ground of the grounding electrode system of two ohms shall be allowed.
3. In the following areas, comprehensive engineering design is required. For these installations, it is expected that the consultant will provide documents completely detailing all of the grounding requirements. Typical installations include, but are not limited to the following:
 - a. Building services and grounding risers.
 - b. Electrical vaults and substations.
 - (1) Ground rod and mechanical system bonding details.
 - (2) Adequacy of existing grounding in building remodels or renovations.
 - c. Secondary distribution systems.
 - d. Separately derived systems.
 - e. Computer and communications rooms.
 - f. Hazardous locations.
 - g. Shop air and gas systems.
 - h. Lightning protection per NFPA 78.
4. Details
 - a. Diagrams covering several standard conditions are included as Standard Drawings SD-E-133 through 139 in the Volume 4 Appendix to be used as guides in developing the grounding systems. The consultant shall include the proposed grounding scheme and details with the design development submittal.



- b. Specify that paint between grounding lugs and enclosures is to be completely removed.
- c. Use multi-terminal lugs and ground bars to accommodate the number of ground conductors.
- d. Bond structural steel column anchor bolts in footings to footing rebar for added lightning protection.
- e. Equipment grounding conductors shall be provided for all raceways and should be so indicated in feeder schedules and branch circuiting representations. Bond to intermediate pull and junction boxes.
- f. Specify exothermic welds for inaccessible connections, and for splices in grounding conductors.

M. Equipment and Conductor Load Calculations

- 1. Normal Power
 - a. Lighting
 - (1) NEC Table 220-3(b). Any VA excess over Energy code allowed VA may be considered spare capacity.
 - (2) Demands in Table 220-11 not applicable.
 - b. Other Loads: Use NEC 220-3(c).
- 2. Emergency Power Systems
 - a. Lighting at 100% load.
 - b. Receptacles and other loads per NEC.
 - c. 100% coincident operating equipment.
- 3. Load Schedules

Indicate panel demand loads on a drawing schedule.
- 4. Show Power

100 amps or 60 amp. Use Hubbel (or Brown Boveri) pen and sleeve three-phase, 5-wire plugs (prefer Hubbel). Disconnects for 200-400 amp show power should be rated at 240 volts, fused and have multiple load lugs if backstage.

H. Equipment and Conductor Sizing

- 1. Service Transformer

See 16A03.



2. Service Switchboards

Switchboards should be sized to handle full forced air cooled capacity of the service transformer as noted in 1603. One spare breaker of each frame size shall be provided with each draw-out switchgear lineup, with multiple tap C.T.'s. Where space only is indicated, provide all bussing and mounting hardware.

3. Distribution Feeders

Distribution feeders serving several floors shall be sized with 25% spare capacity based on the calculated demand load for the feeder. The feeder capacity shall be based on the code allowable capacity of the cable and overcurrent protective device. 800A maximum riser feeder size. Multiple riser feeders shall be provided where additional capacity is needed.

Need additional capacity for show power. Disconnects, plugs should be located for show power. Establish a pint sleeve plug (Hubbel or Asea Brown Boveri).

4. Distribution Switchboards and Panels

Size equipment and source feeders to carry the calculated demand load plus 25% spare ampacity. The switchboards and panels shall have 25% spare breaker space. Need larger load capacity for show power.

5. Transformers

Transformers shall be sized to carry the calculated demand load, with at least 25 percent of their capacity reserved or spare. (See also 16A05.) The use of special transformers, or additional space capacity allowances may be necessary to compensate for excessive harmonic currents.

6. Branch Panels

Size panels and their source feeders serving mainly lighting and receptacle loads for their calculated demand load plus a minimum of 30 percent spare capacity for lighting and 40% for equipment and outlets. All lighting branch panels shall have 20% spare breaker space, and all receptacle and equipment branch panels shall have 25%. (See also 16A05.) May need more for show power, with disconnect and plugs.

7. Branch Circuits

See paragraph J.2.b of this section and 16A05 for loading calculations for branch circuits.

8. Remote Power Accommodations

(2) disconnects with plugs shall be supplied in the main electrical room of the building to accommodate remote power needs for show power. (One 200 amp 208V-3Ø disconnect and plug to be provided in each location.)

Buildings used by the public shall have at least one 60 amp three-phase, 5-wire Hubbel pen and sleeve plug at each entrance or side of building.



4. 16A06 -- Motors and Controls

A. Scope

1. These standards and procedures apply to the selection and installation of motors and controls whether furnished under the electrical, mechanical, architectural, or other divisions of contract. Coordinate all requirements and references with other divisions.
2. Packaged equipment with prewired central panels shall have the same type of indicating lights, identification of wiring and components, and as necessary to comply with this section.
3. Index

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B. Design Criteria

1. Design Review and Submittal
 - a. The type of control for every motor must be identified in the specifications or on the drawings.
 - b. Controls in motor control centers shown on electrical drawings must be verified by the mechanical engineer for compatibility with the control requirements.
2. Codes, Regulations, and Standards
 - a. Motors and controls shall conform to N.E.M.A. standards for each specific purpose and application. Where applicable they should be installed following systems capability analysis including consideration of harmonic distortion.
 - b. Conform to Seattle Energy Code.
3. General Requirements
 - a. Motors and controls shall be manufactured by a reputable company recognized in its respective field. Preferred manufacturer for motor controls is Cutler Hammer.
 - b. Identification.
 - c. Caution labels warning against frequent starting of motors may be necessary, or lockout controls with thermal sensor in motor windings.
 - d. As part of the as-built drawings, each motor shall have a control diagram indicating what devices are controlling it, where they are located, their identification name or number, and what they are supposed to do. Relationships between devices (priorities) and timed functions should be noted. The engineer



shall provide specification wording and coordination with the work of other divisions to make certain the electrical contractor performs the work. Show typical diagrams on the drawings.

C. Specific Requirements

1. Motors

- a. Motors shall be high efficiency energy conservative models, meeting the ASHRAE 90.1 requirements.
- b. Voltage ratings for motors shall be as follows:
 - (1) Less than 1/2 horse power (hp): 120 volt, single phase if readily available.
 - (2) 1/2 hp and larger: continuous operation 460, 460/208, 3 phase. Connect to 480 volt source when available, 208 volt is acceptable for smaller motors where 480 volt is not available. For 1/2 HP sizes for intermittent light duty where energy consumption is minimal, such as sump pumps, door operators, unit heaters, etc., 120 volt operation may be used for first cost savings.
 - (3) Over 150 hp: coordinate with Plant Engineering and Electrician.
- c. Motor speeds shall be matched to the driven equipment. Heavy fan drive motors should be 1,200 rpm or less.
- d. Motors must be rated for "continuous duty," and shall be oversized to avoid tripping..
- e. Motors shall be open drip-proof construction. Totally enclosed or explosion-proof types shall be provided where conditions dictate. Aluminum components are not acceptable.
- f. Motor bearings shall be sealed. Sleeve bearings will be permitted for fractional horse power motors and where specifically recommended by the equipment manufacturer as the better type of bearing for the application.
- g. Vertical shaft motors for special application shall be equipped with suitable thrust bearings.
- h. Fractional horse power motors for unit ventilators and similar applications should be carefully selected with respect to speed, load, and starting torque characteristics. Shaded pole-type motors are not acceptable.
- i. Avoid exposing motors to the weather; install in penthouses or other suitable enclosures. Motors installed in equipment exposed to the weather shall be totally enclosed type, even though a weatherproof enclosure is provided.
- j. Motors used in communication with variable frequency drives shall be matched for full operating range of that drive. Provide necessary isolation or conditioning such



that harmonic distortion is addressed and will not be an issue for the power system associated.

2. Power Factor Correction

- a. Induction motors rated 15 hp and over shall be equipped with capacitors for power factor correction to 0.95 minimum. Capacitors should have blown fuse indicator lights. Capacitors shall not be used with variable frequency drive applications.
- b. Capacitors shall be connected downstream of motor overloads. A location near the motor and fed from the load side of the local disconnect is preferred. May be fed from starter "T" leads if no disconnect. Motor overload devices must be properly coordinated.
- c. Capacitors shall be connected to correct power factor to 0.95 for motor control center buses serving more than 15 total horse power of small induction motors.
- d. Verify and record power factor after building systems are operational and HVAC system balanced. Verify transform load and supply harmonic load analyses.
- e. Capacitor not required for motors controlled by variable frequency drives.

3. Motor Controls

- a. All motors must be provided with proper motor starting and overload protection devices. Overload protections shall be provided in all three phases for three phase motors; in all "hot" legs for single phase motors.
- b. Combination circuit breaker starters are preferred over separate components. Fusible switch types are generally not allowed. Motor control centers shall be used in lieu of distribution panels and separate starters in mechanical rooms and other multi-motor installations.
- c. Determine short circuit rating by calculations, with consideration given to future system changes.
- d. Motor controls shall be provided as follows:
 - (1) Manual starters (non-magnetic type): for single phase motors which do not require remote or automatic control.
 - (2) Magnetic Starters
 - (a) All motor starters shall have selector switch "Hands-Off-Automatic" controls with magnetic starters: for all three phase and single phase motors.
 - (b) Automatic control requirements shall be coordinated with other equipment operations, automatic control by the temperature regulation system, float controls, central supervisory controls, etc.



- (c) Leave the automatic position open for motors without an automatic control.
- (3) The manual position shall never have any automatic controls except for safety and equipment overload protection. The automatic position shall be used for any automatic control including freeze stats, load shed, smoke control, remote manual control, and process control. The automatic and manual positions shall have status contacts wired to the starter control terminal strip for smoke control fans and other critical motors.
- (4) Only intermittent, task oriented motor starters shall have locally mounted "start-stop" push-button control (in addition to the starter HOA). If safety is a concern, local emergency stop buttons shall be provided.
- e. Full voltage starters shall normally be used. Reduced voltage starters must be used in case of motors over 60 hp, limited power supply, or unusual load characteristics.
- f. Large compressor-type equipment must have automatic controls to "unload" the machine during start-up.
 - (1) Utilize autotransformer type unless variable speed required by process or energy code.
- g. Variable frequency drive (VFD) specifications:

GENERIC AC MOTOR SPECIFICATIONS

Nema B
 Class B or better insulation; F preferred
 1.15 Service Factor
 1,750 rpm preferred for inverter service
 Winding thermostat for best protection
 Enclosure, oversized 120-150 % - Nema 4 enclosure
 Designate an acceptable efficiency range

GENERIC AC DRIVE SPECIFICATIONS

Constant voltage dc bus with mov on input rectifier

Voltage	Rated +10%, -6% (or 10%)
Min. power factor	95%
Harmonic content	95%
Allowable temperature rise	Not less than 40 degrees C
Altitude, standard	3300 ft.
Humidity	5 to 95%, non condensing
Vibration	1.0 G
Output power	Pulse width modulated
Enclosure	To suit ambient
Ride through on power drop	3 Hz minimum
Readouts	Frequency, Current, Fault



- h. Controls exposed to weather or severe moisture conditions shall have N.E.M.A. type 4 enclosures. This includes area where storm water or chemical pipes are located. Type 3 enclosures are not acceptable.
 - i. Push-buttons, selector switches, pilot lights, etc., shall be heavy duty "oil-tight" devices.
 - (1) Control and pilot light circuits shall operate at 120 volts. 480-volt starters shall have internal control transformers. Motor control centers may utilize a common control transformer if each unit is separately protected by a control circuit fuse or breaker.
 - (2) Every control and remote push-button shall have an "on" pilot light.
 - (a) Red "on" pilot light and "off" push button.
 - (b) Green "off" pilot light and "on" push button.
 - j. Coordinate locations of remote and central control and annunciation panels with Plant Engineering.
 - k. Lockout safety disconnect switches shall be provided in sight of motors. Disconnects shall be horsepower rated, number of poles required and shall have lock-open features.
 - l. Motor controls not located in motor control centers shall be located adjacent to the motor served; either wall mounted or mounted on an angle iron frame or framing channel supported from the structure.
 - m. Motor shall have sealed bearings.
 - n. All VFD (variable frequency drives) must have bypasses and be oversized by 120-150%. All drives shall have harmonic distortion conditioning. Allon Bradley preferred, Graham acceptable. VFDs shall shut off at 50 Hz to prevent problems.
4. Motor Control Centers
- a. Provide motor control centers in mechanical rooms and other "multi-motor" locations.
 - b. Foregoing requirements for motor controls shall apply to controls in motor control centers.
 - c. Motor control centers shall be standard manufacturer design and construction to permit ready installation, removal, or replacement of standard components.
 - d. Construction shall be N.E.M.A. Class I or II, Type B with unit terminal strips only.
 - e. Vertical wiring spaces shall be accessible from the front without opening individual control units, with hinged cover and captive screws.



- f. Units shall be located so as not to be subjected to high ambient temperatures, and not be in close proximity to radiant heat source.
 - g. Starter units shall be minimum N.E.M.A. size 1 for uniformity and maximum interchangeability and shall be the circuit breaker combination type.
- 5. Motor Starter Stations
 - a. Locally mounted motor starters shall be NEMA 1 enclosures for general use and NEMA 4 for damp and wet areas.
 - b. The foregoing requirements for motor controls shall apply to controls in motor starter stations.
 - c. Starters shall be minimum NEMA size required for service.



5. 16A07 -- Lighting

A. Scope

1. These standards and procedures apply to the design and installation of illuminating systems including fixtures, switching and specialized control requirements. Compliance with the Seattle Energy Code is necessary.

2. Index

Title Paragraph

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B. General Design Criteria

1. Illuminating systems shall be designed in accordance with the latest engineering practices and standards, including energy conservation.
2. Installations shall meet high standards of quality, comfort, and maintainability.
3. All lighting must be controlled by local switching. Standard circuit breakers must not be utilized for general switching applications. Low voltage switching systems with master "off" lighting control are encouraged for larger buildings.
4. Lighting layouts must be coordinated with the architectural design so as to control interior and exterior brightness. Non-glare surface finishes with maximum reflection factors and minimum deterioration are encouraged for fixture finishes.
5. The following average maintained lighting levels will be adhered to. Changing energy code requirements will have to be considered. Higher levels may be required where specified in the building program, or where required to meet a special visual task, or where required by the standards of a fund granting agency. For further details concerning lighting levels, refer to the latest edition of the IES Lighting Handbook.
6. Average Maintained Levels in Foot Candles at work surface using 80% maintenance factor.



100 -	200	Arenas - Sport event floor area of arena
70 -	100	Drafting rooms, special laboratories
50 -	70	Offices, classrooms, lecture rooms, shops, kitchen, etc.
T	30	Auditoria, conference rooms
T	20	Restrooms, mechanical and electrical rooms, locker rooms, etc.
T	10	Corridors, passageways, stairways, storerooms, etc.

7. Minimum Maintained Levels

- T 5 Covered parking garages
- T 1 Open parking
- T 1 Roadways (use IES recommendation to suit security level)
- T 1/2 Walkways (use IES recommendation to suit security level)

8. In the interest of energy conservation, the lowest reasonable ambient illumination level will be encouraged with the balance of the volt-amp allowance used for task lighting. Multiple switching and split circuiting will be preferred to constant higher light levels. Task lighting should be maximized.
9. For stock and maintenance purposes, 4 foot fluorescent lamps and fixtures are preferred.
10. Provide ground fault protection on exterior lighting circuits.
11. Convenient means must be provided for relamping, cleaning, repairing, or replacing lighting fixtures. Special consideration must be given to fixtures mounted in high or other inaccessible or hazardous locations by providing chain or cable-operated disconnecting hangers, winches, catwalks, overhead access, etc.

C. Emergency Lighting

1. Exit signs must be provided in accordance with the Seattle Building Code. Sufficient stairway and corridor pathway lights should be provided on the emergency lighting circuits to permit safe passage through the building and so a person does not have to pass through an unlighted space to reach an exitway. For an example, a lab or reception area that has perimeter dedicated offices needs emergency lighting. Our preferred manufacturer for exit lights is Lithonia part number LQM SW 3G 120/277 ELN.
2. Emergency lighting shall also be provided in mechanical and electrical rooms. Position fixtures over equipment control stations and pathways. Our preferred manufacturer for emergency lights is Lithonia part number ELM 4.
3. Lights utilizing incandescent lamps for wall mounted corridor lights, exterior step lights, and theater aisles shall be equipped with half-wave rectifiers for long lamp life (or use long life lamp such as used for traffic signals).



4. Exit signs shall be determined by City electricians and used consistently.
5. Emergency Circuits: Exit signs and pathway lighting fixtures shall operate 24 hours per day or be controlled by local "fail-safe" photoelectric controls or occupancy sensors.
6. Light fixtures in stairways shall be mounted on the wall or pendant mounted at a height of 8'-0" (not at the ceiling).

D. Roadway and Pathway Lighting

1. Streets and parking lots will generally be illuminated with pole mounted, high pressure sodium vapor or metal halide fixtures as indicated on Standards Drawings SD-E-147.
2. Sidewalks and pathways shall be illuminated with pole mounted, metal halide fixtures as indicated on Standards Drawings SD-E-148.
3. Street lights shall normally be spaced at 100 to 125 foot intervals on one side only. Walkway lights shall be spaced 50 to 60 feet.
4. Pole-mounted fixtures shall be served from existing street light circuits wherever possible. New services shall be controlled from existing master circuits where feasible. Outlying services shall be photoelectrically controlled. Existing systems are astronomical timeclocks and some have photoelectric back-ups.
5. All street and walkway lighting fixtures shall be individually protected by an in-line waterproof fuse holder located in the pole base. The fuse shall be on the line side of the ballast.
6. Provide grounding terminals in each pole base or fixture.
7. Street light fixtures shall be labeled and identified. See SD-E-147.
8. Preferred manufacturer for outdoor lighting is Cooper Lighting.

E. Products

1. Lamps
 - a. Unless approved by Electrician, lighting systems shall be designed for use with T-8 lamps. When operated at 265 ma., the T-8 lamp shall provide 2580 initial lumens. All lighting systems shall utilize fluorescent, metal halide, high pressure sodium vapor, or other long-life types of lamps. U-bent lamps shall not be installed. Bias lamps shall be used in 2x2 fixtures or where a U-bent was previously used.
 - b. Generally, the use of incandescent lamps will be permitted only where ambient lighting is required due to excessive relamping costs, power requirements and effects on the environmental control equipment. Compact fluorescent fixtures may be used for limited architectural effect.
 - c. Corridors shall generally be illuminated with fluorescent lamps, however, metal halide or high pressure sodium may be used if designated, and instant start or other lighting to cover the restrike period is provided.



2. Magnetic Fluorescent Ballasts

- a. Ballasts shall be UL and CBM approved, Class "P" energy saving, high power factor, and shall be of a type with the lowest available sound rating for the type of lamp. Ballasts shall contain a thermosetting fill material of a non-coal-tar product and shall contain no PCB's.
- b. Each ballast shall be individually fused with an in-line fuse holder, Bussman type HLR, or equal.
- c. For installations using HO and VHO fluorescent lamps; consider the use of extended life ballasts for a nominal 20 year life with reduced wattage lamps.
- d. Ballasts for high pressure sodium and metal halide lamps shall be constant wattage type.
- e. Preferred manufacturer for ballast is Advance Electronic Dimming (2 wire).

3. Electronic Fluorescent Ballasts

a. Power Input Side Requirements

- (1) Light output shall not vary in response to an input voltage variance of less than 10% of rated voltage.
- (2) Power Factor shall be greater than .98 at full light output. Dimming ballast power factor shall remain greater than .93 at all reduced light output levels.
- (3) Line Current Crest Factor shall be between 1.3 and 1.5.
- (4) Total Harmonic Distortion shall be less than 10%.
- (5) Third Harmonic (180 Hz) Distortion shall be less than 8%.
- (6) Transient Protection: Meets IEEE 587, Category A requirements.

b. Output Requirements

- (1) Drive output shall be approximately sinusoidal with a Current Crest Factor between 1.3 and 1.5.
- (2) Drive output frequency shall be greater than 25 Khz and result in less than a 2% lamp flicker.
- (3) Ballast shall be full Rapid Start.
- (4) Dimming ballasts shall maintain full filament heat during operation.
- (5) Filament start power shall not 5 watts.

c. General



- (1) The ballast shall be a standard product of the Manufacturer that has been in production for three years, and be acceptable under the utility rebate program.
- (2) Ballast shall be Underwriters Laboratories listed, Class P. Ballast shall be provided with in-line fuse holder (Bussman type HLR or approved).
- (3) Ballast shall have a sound rating of A or better.
- (4) Ballast shall meet FCC CFR 47 Part 18 Class A requirements.
- (5) Lamp failure shall not adversely impact ballast reliability.
- (6) Information sheets shall be provided for all ballasts including replacement part numbers and sources.
- (7) Preferred manufacturer for ballast is Advance Electronic Dimming (2 wire).

4. Fixtures - Fixture Construction and Installation

Minimum number of fixtures in a building: Minimize amount of lamp parts. Fixture stated in bid shall not be replaced with substitute unless pre-approved with a sample of the future. Fixtures shall be available locally or available in a reasonable period of time. If European or from another country all parts shall have a local stock. Parts and fixtures must be available within two weeks to one month. All color standard stock.

- a. All lighting fixtures shall be of high quality construction, designed for long life and easy maintenance. The use of high efficiency metallized reflectors is encouraged for energy conservation and maintenance.
- b. Fixtures should be designed with simple contours for minimum dust collection.
- c. Replacement parts should be readily available and easily secured from the manufacturer/supplier.
- d. Enclosing glassware or plastic diffusers shall be designed with standard dimensions for ready replacement. Generally, fixtures should have diffusing members designed as flat plates so out-of-stock fixtures can be repaired from sheets of commercially stocked glass or plastic. Enclosing globes, louvers, or diffusing panels shall be of sturdy rigid construction, designed for ease in opening, closing, or removing. Diffusing lens shall be of framed, hinged construction. Frameless lenses are undesirable.
- e. Plastic diffusers of 0.125" minimum thickness virgin acrylic are acceptable elsewhere. In areas where TV or computer screens are used, lighting systems shall be selected with low glare and high VCP (visual comfort probability) rating. Vinyl plastic and sheet styrene lenses are not acceptable.
- f. Pendant-mounted fluorescent light fixtures should generally be selected to produce not less than 10 percent up-light.



- g. Fluorescent lamps sockets shall be high quality, heavy duty, silver plated type; rigidly supported. Sockets with "spring grip" wiring terminals are not permitted.
- h. Fluorescent fixtures for use in lay-in ceiling grids shall be wired to junction boxes with flexible conduit, factory installed long leads fed through an installed flex conduit conductor so that the fixture does not have to be opened up by the installing electrician, or "prewired" systems.
- i. Pendant fluorescent fixtures shall be supported with one hanger 6" to 24" from each end of the fixture with a minimum of two hangers per 8' of fixture.
- j. All lay-in fixtures shall have seismic safety chains, or code approved seismic mounting.
- k. In fire rated ceilings, the fixture installation must also comply with the U.L. construction requirements of the ceiling listing.
- l. Identify at the socket HID and 277 volt medium base lamp holders with the proper lamp voltage.

5. Exterior Lighting Fixtures

Building entrance, landscape and courtyard fixtures shall be suitable for the location, shall be metal halide and shall be controlled with astronomical time clock with photo-electrical backup. Fixtures shall be heavy duty cast metal construction designed to withstand normal weather conditions. "Sheet metal" type fixtures are not permitted. The primary exterior pole fixture shall be Gardco Lighting MPG.

6. Controls

- a. All lighting controls shall be pre-approved by electrical department and in cases of show and house lighting the stage department also. Any sophisticated controls shall be demonstrated before approval. All control programming shall be demonstrated and programming literature available before approval. Detailed programming instructions shall be made available before approval.
- b. Automatic controllers and electronic astronomical time clocks shall have reserve power feature or battery backup.
- c. Lighting control relays and contactors shall be located away from occupied spaces (classrooms, auditoriums, and offices) and be accessible. Latching type relays will be used. They will not be in ceilings unless absolutely necessary.
- d. Systems utilizing a carrier frequency for control shall not be used.
- e. Locate photo cells in protected accessible areas, facing north.

End of Section 4